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XXIV.—*On the Theory of the Fecundation of the Ovum.* By E. Claparède*.

One of the first discoveries which followed the invention of the microscope, or at all events one of those which made the most noise in the world, was the discovery by Ludwig von Hammen of the spermatozoids in the seminal fluid. This was the commencement of a new æra in the physiology of fecundation, an æra however which must unfortunately be characterized rather by the accumulation of fruitless theories, than by the discovery of a great number of facts. These spermatozoids, these mobile particles of the animal semen, were at first raised to the rank of independent beings, as spermatic *animalcula*, and although their title to this place in the series of beings is nowadays pretty generally disputed, this antiquated opinion is still far from being completely banished from the domain of science. The theories took their course, and Gautin did not hesitate to attribute to the animalcula of the human semen, the actual figure of *Homo sapiens*. Others made them penetrate into the ova and form the embryo. Andry †, mixing poetry with matters with which it had nothing to do, related how each spermatozoid arrives in the ovary and penetrates into the egg, by passing through a little door, which it pulls after it and shuts with the assistance of its tail. He even went so far as to represent these little creatures engaging in sanguinary combats at the door of the ovum, and disputing each other's right of entrance with such determination that many lost their arms and legs. Hence arise

* Translated from the Bibliothèque Universelle de Genève for August 1855, p. 284, by W. S. Dallas, F.L.S.

† See Vallisneri, Istoria della Generazione dell' Uomo e degli Animali. 1721.

miscarriages and deformed children. Leeuwenhoeck contented himself with conveying them into the uterus, where they changed their skins like caterpillars and became transformed into men. Lastly, to come to modern times, according to Prevost and Dumas*, the nervous system of the embryo is a product of the zoösperm, whilst the plastic and irritable organs are formed at the expense of the ovum.

For a long period warm disputes prevailed between the *ovists* and the *spermatists*. The principal representatives of the former were Malpighi, Antoine Vallisneri †, Haller ‡ and Bonnet §. Their greatest stumbling-block was the part to be assigned to the seminal fluid. Bonnet and Haller imagined that it might constitute the nourishment of the embryo. It is for this reason, according to them, that a mule has long ears, because the semen of his father, the Ass, contains a large quantity of quintessence of ear, &c. They did not trouble themselves with the obstacles which this opinion might throw in the way of the theory of the inclusion of germs. Some even refused to admit that the spermatozoids were of any importance; like D. Parsons ||, who declared it to be "an extreme nonsense" to believe that those insignificant creatures called spermatic animalcules could contribute in any way to propagation. Daubenton and Needham ¶ only regarded them as a product of the decomposition of the semen; and we owe some gratitude to Bonnet and Gleichen ** for having demonstrated by experiment that the seminal fluid of hybrids was incapable of fecundation because it contained no spermatozoids, which however has not prevented Sir Everard Home †† in our own century from denying their existence entirely.

Nevertheless the spermatists appear to have carried the ridiculous still further than the ovists. As a foretaste we have already given a sketch of Andry's romances. He attributed the nature of the animals to their spermatozoids; thus those of the sheep lived in flocks even while still in the testicle and epididymis. Santanelli regarded them as cylindrical spirits with five points. But the first spermatist was undoubtedly Aristotle ‡‡,

* Annales des Sciences Naturelles, ii.

† *Op. cit. sup.*

‡ Elementa Physiologiæ Corporis humani. Lausannæ, 1757–1766.

§ Considérations sur les corps organisés.

|| Philosophical Observations on the Analogy between the Propagation of Animals and that of Vegetables. 1752.

¶ Notes des nouvelles recherches sur les découvertes microscopiques de l'Abbé Spallanzani. Londres, 1769.

** Abhandl. über die Samen- und Infusionsthierchen. 1788.

†† Lectures on Comparative Anatomy, vol. v. 1828.

‡‡ See his works Περὶ τῆς γενέσεως and Περὶ ζωιῶν μορίων.

who declares that the actual procreant element is the male, whilst the female element only furnishes nourishment. The ovists, as well as many spermatists, were partisans of the theory of the preformation or evolution of germs, a theory which soon gave place to that of metamorphosis. Bonnet himself appears to have had a tendency this way, for he puts forward the idea, that the air, the water, the earth and every solid body, are magazines containing germs. The same germs, which, passing into plants produce buds and flowers, give birth to embryos when they penetrate into the ovaries of animals *. In reality this is not far from the opinion of Heraclitus, who maintained that the germs were diffused everywhere, and that they were developed as soon as they arrived in the proper sexual organs. Perrault, Needham, Buffon and Treviranus merely worked out this kind of panspermism in various directions, until Oken † imagined that these universally diffused germs were to be found in the Infusoria.

It must be confessed that the imagination of our forefathers was very prolific in the fabrication of theories of generation which often approached pretty closely to the ridiculous, or at all events to the comic. However, all these beautiful edifices crumbled one after the other by their own weight, and of late years there appeared to be a tacit agreement between physiologists, by which they engaged to steer clear of this subject until they had facts before them. But in the absence of facts, it was necessary to rest contented with the general ignorance, which however was soon veiled in a tinsel cloak, by having recourse to a *force*, that *deus ex machinâ* which physicists, chemists, physiologists and other philosophers use and abuse in accounting for that which they cannot explain.

People accordingly admitted a dynamic action of the zoosperm. This arrived at the ovum, without however penetrating into its interior, as Andry's little door did not exist; and by its simple presence, in virtue of a force belonging to its predicate of spermatozoid, fecundation was effected, but no one knew very well how or why. The embryologist Bischoff was one of the principal defenders of this dynamism, which, indeed, was nothing

* The author here appears to have mistaken Bonnet's meaning in some unaccountable manner; his statements seem to have a directly opposite tendency. Thus in stating his hypothesis of the universal diffusion of germs he says, "they only become developed when they meet with suitable matrices, or bodies of the same nature;" and in a subsequent passage he adds, "it is only the germs which contain organic wholes, of the same kind as that into which they are introduced, that are developed there."—W. S. D.

† Die Zeugung. Bamberg, 1805.

but a reproduction of Harvey's * ideas, when he compared the action of the spermatozoids upon the ovum to that of the magnet upon iron, or when, with Osiander and Treviranus, he called it a *contagion*.

The reign of the old theories appeared to be repudiated for ever, and it was scarcely expected that they would soon have raised their heads again to claim the attention of true observers, no longer taking the title of *theories*, but rather that of *facts*, and demanding no other judges than eyes and a sound intellect. This is nevertheless what took place. As early as 1840, a distinguished English observer, Dr. Barry†, in a memoir on the embryogeny of the Rabbit, devoted a chapter to the fecundation of the ovum, and asserted that he had seen this take place under his eyes. According to him the germinal vesicle of the ovum of the Rabbit neither dissolves nor bursts, as was generally supposed; but at a period preceding that of fecundation it becomes filled with cells, which render it opake, and then proceeds in the direction of the periphery, towards the *zona pellucida* (*transparent membrane*). The latter presents *an attenuation or an orifice* at the point approached by the vesicle. This, at least, is what Barry asserts that he has seen several times in perfectly ripe ovules, even *ante coitum*. The form of the orifice in question was sometimes such as to suggest the idea of a rent or *cleft* in the membrane; in other cases it appeared as though there had been a previous attenuation of the membrane. Subsequently‡ Dr. Barry again described this phænomenon in greater detail. With him the nucleolus of the germinal spot is a peculiar substance which he calls the *hyaline*. In this hyaline resides the *force* (the explanation again leaves nothing to be desired!) which drives the vesicle towards the *zona pellucida*. When the germinal vesicle comes in contact with the membrane of the egg it bursts, and at the same time an opening is formed in the latter (*zona pellucida*). All this is the work of this hyalinic energy! However, an opening, whether formed or not by the action of the hyaline, was observed in 1840 by Barry in the ovum of the Rabbit, and on one occasion he even perceived in this aperture an object "much resembling a spermatozoon." All these phænomena of course take place before the formation of the chorion, that is to say in the ovary, or in the uppermost part of the oviduct. Two or three years afterwards Barry § announced positively that he had seen not only an object "much resembling a spermatozoon," but actually true zoosperms in the ova of

* Exercit. de Generatione Anim. 1651.
† Phil. Trans. 1840.
‡ Müller's Archiv, 1851.
§ Phil. Trans. 1843.

the Rabbit. Important as this assertion was, it did not make much noise in the world. Barry's discovery passed again into the shade and no one took it up on the Continent. Bischoff* contented himself with mentioning it repeatedly as erroneous and describing it as a mere product of the imagination (*Geburt der Phantasie*).

For twelve years Barry's discovery slumbered. At the end of this time one of his countrymen, also a good observer, Dr. Nelson†, of Glasgow, revived the question by publishing an observation analogous to that of Barry, although relating to a very different animal,—an intestinal worm, the Ascaris of the Cat (*Ascaris mystax*). According to Nelson the ova of this worm, at the period when fecundation takes place, are entirely destitute of vitelline membrane, and possess no envelope of any kind. They are, generally, triangular, or rather pyramidal in form, in consequence of their being pressed against one another in the oviduct. Nevertheless their margins are sufficiently well marked, in consequence of the cohesion of the yelk: at one of the angles alone the outline is less distinct, for which reason Nelson gives this angle the name of the "broken edge." After copulation, the spermatozoids, which, in consequence of their form, the author denominates "spermatic cells," penetrate into the oviduct, reach the ova and insinuate themselves into the substance of the vitellus. According to Nelson, this penetration of the spermatozoids into the ovum takes place at any point of the surface, and even at several points on the same ovum at once; but he remarks that the spermatozoids appear to prefer the "broken edge" for this purpose. As soon as they are in the egg, the "spermatic cells" begin to disappear, probably by dissolution, and their place is occupied by a transparent liquid. In this phænomenon consists the whole system of fecundation. The ovum immediately begins to undergo modifications. The vitellus acquires a spotted appearance, previously noticed by Reichert in *Strongylus*, and considered by that anatomist as the result of the formation of cells in the interior of the yelk; the existence of these cells in this *Ascaris* is completely denied by Nelson. The germinal vesicle bursts, and its disappearance is immediately followed by a modification of the granules of the vitellus, which become transparent. After this transformation Nelson proposes to give them the name of embryonal granules. In the interior of the egg, a cell with a nucleus and nucleolus is formed; these are the blastodermic vesicle and spot. Whilst these things are

* Entwickelungsgeschichte des Kaninchencies, 1842,—des Hundecies, 1845,—des Meerschweinchens, 1852.

† Phil. Trans. 1852, part 2.

taking place, the chorion is formed, and the egg continues advancing by degrees towards the period of its segmentation and the formation of the embryo. The action produced upon the ovum by the spermatozoids is consequently, according to the Glasgow physiologist, of a triple nature:—1. A preservative action, inasmuch as they prevent the destruction and disappearance of the vitelline granules, and their indiscriminate mixture with the elements of the germinal vesicle and spot, which, according to him, inevitably takes place when the ova are not fecundated; 2. A destructive solvent action, in consequence of which the vitelline granules and germinal vesicle are gradually dissolved at the expiration of a certain time; and 3. A transforming action by which the vitelline granules are metamorphosed into embryonic granules.

It was reserved for a third English philosopher to assist in the formation of the new edifice, by the announcement of the entrance of the spermatozoid into the ovum in a third class of animals, namely the Reptiles. Newport* in his first memoir on the reproduction of the Batrachia, had referred to various experiments which he had made with the view of throwing discredit upon the opinion that the spermatozoids could penetrate into the ovum, which he regarded as possessing but little probability. But a year-and-a-half afterwards† he recalled his previous opinion in a remarkable memoir, in which he stated that he had positively seen spermatozoids, not only within the outer membranes of the ovum of the Frog, but actually in immediate contact with the vitelline membrane. The spermatozoids had their heads always directed towards the centre of the ovum and their tails towards its periphery, as though they wished to penetrate still further. The first consequence of the fecundation thus effected, consists, according to Newport, in the formation of a chamber between the vitellus and the vitelline membrane at one extremity of the egg, and the segmentation of the yelk then commences. In a note written subsequently to the communication of his paper to the Royal Society‡, Newport announces that he had actually observed the passage of the spermatozoids through the membranes of the ovum and their arrival in the interior of the vitellus. He remarks that the penetration does not take place through a particular opening, but through any point of the surface of the chorion. "The spermatozoa," he says, "do not reach the yelk of the Frog's egg by any special orifice or canal in the envelopes, but pierce the substance of the envelopes at any part with which they may happen to come into contact."

* Phil. Trans. 1851. † Phil. Trans. 1853, part 2.
‡ Phil. Trans. 1853, part 2. p. 271 (*note*).

These three discoveries of the penetration of the spermatozoids into the ovum were soon to be followed by several others. In fact, we are arriving at the moment when this new theory, or rather, this resurrection of antiquated ideas now founded upon observation, was to excite general interest, and bring into the arena all the distinguished names of which physiology can boast.

Shortly after Newport's discovery, there appeared at Königsberg a work by a M. Keber* of Intersburg,—a work which came forth with the pretension that it would change the face of science, and convulse with astonishment, not only Königsberg, not only Germany or Europe, but the whole world. The work was published in two languages, German and Latin, in order that no one should have an excuse for want of knowledge of the new doctrine, for ignorance of the truth. "I shall prove by innumerable observations," is the pompous announcement of Keber in his preface, "that no animal fecundation takes place but when the spermatozoids penetrate into the ovum, divide in the vitellus and form the nuclei of the cells of the new organism. . . . I feel all the weight of this bold assertion; I know that I am about by this means to place myself in opposition to the Coryphæi of science, and that more than one, offended at hearing such an absurdity, will throw this work aside contemptuously, without reading it, or perhaps at the utmost, will grant it a place in the series of scientific curiosities. But I have carefully and conscientiously convinced myself of the truth of my assertions, upon more than 2000 eggs," &c. Exclaiming, with Aristotle, that one must have more confidence in one's own eyes than in the opinions of others, Keber proceeds, without disturbing himself about the objections which may be raised against him, or dreaming that Aristotle spoke of the eyes of reason and not of those of the imagination.

But let us pass to details, and first of all, to the phænomena which Keber pretends to have observed in the *Naiadeæ* (*Anodonta, Unio*). According to him, the ovum in these Mollusca is not enveloped simply in the cortical membrane (*Schalenhaut* of Baer); but within this there are two others,—the membrane of the albumen and the vitelline membrane, the former separating the albumen from the cortical membrane, the second from the vitellus. The young ova present a cæcal prolongation, which arises from the membrane of the albumen and, piercing the cortical membrane, forms a projection externally. In some cases a fine membrane is perceptible uniting this process with the ger-

* Ueber den Eintritt der Samenzellen in das Ei, ein Beitrag zur Physiologie der Zeugung. 1853.

minal vesicle. When the ova become larger, the extremity of the cæcum opens and a small quantity of albumen passes out from it; this is to serve as a bait to the spermatozoids (! !). The ovum then exactly resembles one of those glass flasks used in chemical laboratories, furnished with a rather short neck. The spermatozoids arrive from all sides, allow themselves to be taken by the bait, and penetrate into the neck of the ovum, or the *micropyle*, to employ a name now received in science. In its frolics the spermatozoid loses its tail, so that only its oval head is found in the neck of the ovum, and this usually occupies a transverse position. It is difficult to describe the ecstasy in which Keber was plunged at this discovery, on the day when he was permitted to see "that which no mortal eye had yet contemplated." Overwhelmed with enthusiasm, and believing himself initiated into the mysteries of creation, he concludes his first chapter by exclaiming (in two languages)—"*And the evening and the morning were the first day*!" (Factumque est vespere et mane dies unus! Da ward aus Morgen und Abend der erste Tag!)!!!

But this is not the whole;—Keber follows the journey of his spermatozoids into the eggs, where he is clever enough to recognize them, sometimes by their form, sometimes by their greenish tint, and sometimes because they begin to jump about (probably they go into convulsions) under the influence of sulphate of strychnine*. The spermatozoid has lost its tail, which greatly facilitates research, seeing that if it was necessary to seek for it in the egg, its delicacy would certainly prevent its being found. But we may be allowed to ask how this spermatozoid is to be distinguished from any other granules, for it is well known the spermatozoids of the *Anodontæ* are far from being of gigantic stature. The idea of a blackish tint being characteristic scarcely needs refutation. The imperfection of our best achromatic glasses still communicates to certain objects a tinge which varies according to the microscope, without taking into account the phænomena of diffraction, which must occur at the edges of a small object situated in the interior of the egg. Henle† indeed speaks of a yellowish tint in the human spermatozoids; but he takes care to add, "in a certain illumination." Besides, as the old proverb says—*De coloribus non est disputandum.* However, Keber pretends to recognize the spermatozoid with certainty and pursues the investigation of its evolution. Week by week he describes the changes which it undergoes, until the moment when it becomes decomposed into granules, which probably

* It is however to be observed that it is precisely this agent that is employed, as well as chloroform and oil of bitter almonds, to deprive the spermatozoids of man and other animals of their mobility.

† Allgemeine Anatomie, p. 949.

afterwards form the nuclei of the embryonal cells. We shall not enter upon these details, as they are rather too romantic. We cannot in any case attach the least credence to them, as long as Keber does not inform us how he succeeded in determining the period at which his supposed spermatozoid entered into the egg.

Keber's discovery is not confined to this. Following in Barry's steps, he pretends to have seen the micropyle in the ova of the Rabbit, and followed the spermatozoids which had just lodged there. His drawings, however, do not agree very well with those of the English anatomist, and it is a curious circumstance that he states that he met with the ovules not only in the uterus and oviduct, but also and especially in the abdominal cavity, in the mesentery, &c. He has even found them sometimes in such numbers in the cavity of the body, that he inquires whether it is not probable that these so-called ova may at a later period reach the uterus by some unknown migration (!). Astonishment will cease when we learn that Keber never saw the ovule of the Rabbit, as has since been proved by Bischoff*. These so-called eggs of the Rabbit, covered with vibratile cilia on their whole inner surface, are a species of hydatic vesicles, furnished with a tubular peduncle, which have been described by Remak† under the name of vibratile vesicles (*Wimperblasen*). They are pretty frequently met with on the mesogastrium and mesometrium of the Rabbit, as well as in the lobes of the thymus gland; and also in the Cat. They are, moreover, found before, during and after the rutting season, and both in young and old individuals. This last mistake is sufficient to detract remarkably from the value of Keber's other observations, especially as he appears to attribute a very peculiar importance to his discovery of the micropyle in the Rabbit, since he has the modesty to compare this discovery, not due to chance, but supported by induction, to that of the planet Neptune by Leverrier and Galle (! !). And yet Keber's conscience was not satisfied as to his fact, for in speaking of these vibratile vesicles, he exclaims, "And if these were not eggs, I should be glad to know what they were!"

Keber's work, notwithstanding all its faults and errors, could not but contain some truths, amongst which we may give the first place to the prediction expressed in his preface, that this volume would astonish many people, and would be arranged by many amongst the curiosities of science. This is a position which it has since attained. Nevertheless, if it had only the

* Widerlegung des von Dr. Keber bei den Najaden, und Dr. Nelson bei den Ascariden behaupteten Eindringens der Spermatozoiden in das Ei. Giessen, 1853.

† Müller's Archiv, 1841 & 1854.

merit of having called attention to the micropyles of the ova of the *Anodontæ*, which are so easily found, that it is sufficient to pass the scalpel over an ovary and place what it takes up under the microscope in order to see them in great numbers, this would be something; but its greatest merit undoubtedly was its energetically inducing the combat. Thus, Bischoff, although apparently a protector of the quarto volume in two languages, inasmuch as it was dedicated to him, could not avoid taking up the pen to put Keber's inexperience into its proper place, not without some brusqueness. It was not so much Keber, he said, as Newport, and especially Nelson, that he came forward to refute; few would be led astray by the verbiage of the former, but the others were philosophers of a much more serious character. Indeed Nelson's observations appeared to have nothing improbable about them, to those who were acquainted with the works of Siebold* and Thaer† upon the Trematode worms, and those of Max Schultze‡ and Leuckart§ upon the Turbellaria. These authors have proved that in these hermaphrodite animals, besides the *vas deferens* which leads from the testicle to the penis, there is a second canal which passes directly to the place where the eggs are formed at the point of union of the canals coming from the vitellogene and the germigene‖; from which it might be considered probable that the spermatozoids passing through the second deferent canal may be enclosed in the ovum at the moment of its formation, so as to fecundate it at once, although these authors did not observe anything of the kind. Bischoff then took upon himself to refute Barry, Nelson, Newport and Keber. The latter had no strength for the struggle and was soon overthrown. The vibratile vesicles (*Wimperblasen*) which he had taken for eggs gave him the finishing stroke.

Leuckart¶ on his side had undertaken to show how the micropyle is formed in the *Naiades*; he had ascertained that it was nothing but the peduncle which attaches the young ovum to the stroma of the ovary, and which afterwards tears away, still retaining the form of the neck of a bottle. T. von Hessling**

* Müller's Archiv, 1836. † *Ibid.* 1850.

‡ Naturgeschichte der Turbellarien. Greifswald, 1851.

§ Troschel's Archiv, xviii.

‖ Or rather from the ovary and the albumen-gland. J. Müller has in fact proved that the so-called germigene contains perfectly complete eggs, so that the vitellogene must descend again to the rank of albuminogene. Siebold himself, who gave these glands the names of vitellogene and germigene, appears now to have returned to this opinion.

¶ Zusatz zu Bischoff's Widerlegung. He had moreover previously described this formation of the micropyle.—Handwörterb. der Physiol. iv. Article *Zeugung*.

** Zeitschrift für wiss. Zoologie, April 1854.

took upon himself the easy task of proving to Keber that he had never seen zoosperms in the interior of the *Naiades*, that he could not consequently have followed their development for weeks, and lastly, that the tailless spermatozoid so often seen by Keber occupying a transverse position in the micropyle, was nothing but the inner opening of the latter. The membrane of the albumen and the vitelline membrane admitted by Keber, besides the cortical membrane in the *Anodontæ* and *Unios*, having no existence in reality, the neck-like micropyle could not be a prolongation of the former; it belongs in fact to the cortical membrane itself.

Nelson's observations, like those of Barry and Newport, were more difficult to refute; but we need not dilate upon the objections raised against them by Bischoff, as the latter has since recognized his error. We may however refer to the fact, that Bischoff asserted that the spermatozoids which Nelson had seen penetrating into the ova of *Ascaris mystax* were not spermatozoids, but epithelial productions, to which he gives the name of *epithelial conules*. These pseudospermatozoids, or epithelial conules, according to him, are scattered between the papillæ of the mucous membrane of the oviduct, from which they are very easily detached; they are wanting, however, in the lower part of the oviduct (*sphincter* of Bischoff), and exist under the papillæ of the uterus. The vagina presents neither papillæ nor epithelial conules.

In conclusion, Bischoff was very harsh in the tone of his refutation, treating the English anatomists in a somewhat patronizing style, and scarcely honouring the unfortunate Keber with a few strokes of his teeth. What was the astonishment of the learned world, therefore, when a few months afterwards it saw a fresh publication of the embryologist of Giessen with the title —"Confirmation of the penetration of the spermatozoid into the ovum, discovered by Newport in the Batrachia, and by Barry in the Rabbit*." In this work, Bischoff says, with a rather solemn tone, "I have repeated Newport's observations and hasten to state that I have confirmed them in every respect, and that there is no longer any doubt that the spermatozoids actually penetrate into the egg of the Frog. After convincing myself of this fact, I again took up the study of the ovules of the Rabbit, and I do not hesitate in stating that I was wrong in contradicting Barry, and that in this case also there remains no doubt that spermatozoids really penetrate into the ova of these

* Bestätigung des von Newport bei den Batrachiern und Barry bei den Kaninchen behaupteten Eindringens der Spermatozoiden in das Ei. Giessen, 1854.

Mammalia." And elsewhere—"It is consequently proved that Newport has the honour of having discovered this curious and unexpected phænomenon of the penetration of the spermatozoid into the ovum, as the result of its own movements. This has nothing to do with the micropyle or anything of the kind; but these singular organic elements possess the property, by means of their so-called tail, of exerting so considerable a mechanical effect as to enable them to traverse the layer of albumen and the vitelline membrane." Further on again—"I assert therefore that I was wrong in the opposition which I made to Dr. Barry, who is certainly the first who saw a spermatozoid in the interior of an egg in general, and of a mammalian ovum in particular, and to him belongs the honour of this discovery."

Bischoff here attributes to Barry only the discovery of the presence of zoosperms in the ova, and not that of their penetration, because he still denies that this penetration takes place in the manner described by Barry, Nelson and Keber, although he does not dispute the presence of the micropyle in the *Anodontæ*. The penetration of the spermatozoa into the ova of the Rabbit and Frog, as also the presence of the micropyle in those of the *Anodontæ*, when once sanctioned by Bischoff, could not be again called in question; for it certainly must have been a disagreeable task for the celebrated embryologist to retract his opinion, after having declared that the penetration of the zoosperms into the ovum could only be maintained by the merest novices in embryology. We owe him all the more gratitude for having thus placed himself above the suggestions of self-esteem, and publicly confessed his own error.

From the publication of this "Confirmation" we may date the epoch in which the existence of the micropyle has obtained a definite place in our physiological knowledge. Nevertheless, even if we suppose that Barry did not see a true micropyle, the honour of the discovery does not pass to Keber. As we have stated, Leuckart had mentioned the micropyle a little while before him, and given an exact history of its formation precisely in the *Unios* and *Anodons*, a history which he has since completed*. According to him, the ovarian vesicles of the *Naiades* consist of a tolerably thick structureless membrane, on the inner surface of which, instead of a proper epithelium, there is a layer of fatty molecular corpuscles, united by a tenacious albuminous mass. It is in this layer that the germinal vesicle with its characteristic spot is *first* formed. This vesicle, with the mass of albumen which surrounds it, soon forms a swelling or lump on the inner surface of the ovarian vesicle. This gradually in-

* Zusatz zu Bischoff's Widerlegung.

creases in size and acquires a granular consistence; it afterwards becomes the vitellus of the egg. Its surface condenses by degrees into a membrane, the vitelline membrane (cortical membrane of Baer), and this at a time when the mass of the vitellus still adheres to the stroma of the ovary (or rather to the ovarian vesicle) by a tolerably broad base. But this base goes on narrowing more and more, whilst the vitelline membrane continues its formation, until the ovum at last only adheres to the stroma of the ovary by a short peduncle like a neck. A transparent liquid is then formed between the vitellus and the membrane, and the peduncle is detached from the ovary. This point of dehiscence is the micropyle of the *Naiades*.

Leuckart is not the only zoologist who had pointed out the micropyle before Keber. In 1850, J. Müller described a canal traversing the external envelope of the ova of certain *Holothuriæ*, particularly *Thyone fusus* and *Holothuria tubulosa**; in 1851 he indicated a similar structure in the genus *Ophiothrix*†. In 1852 his son Max Müller described the micropyle in the egg of *Sternaspis thalassoides*‡. All these discoveries had preceded that of Keber, but they had not led their authors to a theory of fecundation, although J. Müller says§—"The comparison of this canal with the micropyle of the ovule of the Phanerogamous plants presents itself so naturally to the mind, that I could not avoid mentioning it here;" and Leuckart‖, in mentioning the micropyle in the *Naiades*, adds—"We might almost suppose that this singular structure has a certain relation with the act of generation." According to J. Müller the micropyles of the ova of the *Holothuriæ* are in the cortical membrane (*Schalenhaut*), besides which there is also a vitelline membrane. Leuckart¶ positively denies the existence of the latter, and gives the name of "vitelline membrane" to that which contains the micropyle. In other respects he describes the formation of the micropyle here exactly as in the *Naiades*;—it is the remainder of the peduncle which attached the ovum to the stroma of the ovary. The formation of the peduncle always depends upon that of the membrane, and as this does not exist at the point of attachment itself, it is clear that there always remains an opening at the place of the peduncle. This is the micropyle.

But Lovén appears to have been the first to perceive the micropyle, for, in a work of his which dates as far back as the year

* Metamorphose der Echinodermen, 4te Abhandl. 1850.
† Monatsbericht der Berliner Akad. 1851.
‡ De Vermibus quibusdam maritimis. Diss. inaug. Berlin, 1852.
§ Ueber die Metamorphosen der Echinodermen, 4te Abhandl. p. 42.
‖ Article *Zeugung* in Wagner's Handwörterbuch der Physiol. iv. p. 801.
¶ Zusatz zu Bischoff's Widerlegung.

1848*, I find the description of the mode in which the ova are formed in the *Modiolariæ* and *Cardia*, which agrees exactly with that furnished by Leuckart for the *Anodons*. He also saw that the ova are prolonged into peduncles at the point where they adhere to the ovarian cæca.

The completion of the "Confirmation" of Bischoff was soon furnished by the classical work of Meissner on the anatomy and development of *Mermis albicans*†, a species of Gordius, which when young inhabits the caterpillars of *Hyponomeuta cognatella*, and which afterwards passes into moist earth, where its generative organs acquire their final development and reproduction takes place. In speaking of the formation of the ova, Meissner incidentally mentions the micropyle. This work is important, inasmuch as it sets forth the homology of the male and female sexual organs, and the analogy between the semen and the ova. The male and female generative organs of *Mermis* are, in fact, perfectly similar and consist of a very long vessel, so that it is impossible to distinguish the internal generative organs of the male *Mermis* from those of the female, unless by the microscopic examination of their contents. The upper part of the generative tube or vessel of the male, the part designated by Meissner as the testicle, is filled with round cells, as clear as water, and composed of an extremely delicate enveloping membrane, an enclosed liquid, and of a large pale granulated nucleus, containing a nucleolus. These are the male *germ-cells* (*männliche Keimzellen*) as Meissner calls them. The nucleus of these cells in the course of its development exhibits a fine line on its surface, which soon becomes a groove and afterwards a constriction, until at last the nucleus divides into two. The nucleole does not divide, but remains in one or other of the secondary nuclei (*Tochterkern*). The secondary nuclei become larger and divide in their turn, and the nuclei of the third series thus formed follow their example, and so on, until we find germ-cells of the size of $\frac{1}{100}$ to $\frac{1}{80}$ of a line, containing as many as twelve or sixteen nuclei, which all finally attain the size of the primary nucleus. Each of these nuclei is soon seen to acquire a clear border,—this is a membrane formed by a differentiation of the central and peripheric parts of the nucleus. This membrane is constantly removing further and further from the centre, and in this way the secondary nuclei (*Tochterkern*) are converted into secondary cells (*Töchterzellen*) which completely fill the primary cell. The latter then bursts or becomes absorbed, and the

* Bidrag till Kännedomen om utvecklingen af Mollusca acephala lamellibranchiata. Aftryck ur Kongl. Vetenskaps-Akademiens Handlingar för ar 1848.

† Zeitschrift für wiss. Zoologie, December 1853.

secondary cells are set free. They are frequently distributed on the surface of a sphere of albumen, as is the case in the Annelida and Gasteropoda; for these cells are merely the parent-cells (*Entwickelungszellen*) of the spermatozoa. We shall not follow the further development of the spermatozoa, as its interest here is but secondary, and we shall pass at once to the formation of the ova. The generative organs of the female, like those of the male, are composed of a simple tube or vessel, in which, starting from the cæcal extremity, Meissner distinguishes different parts under the names of *germigene* (*Eierkeimstock*), *vitellogene* (*Dotterstock*), *albuminogene* (*Eiweissschlauch*), oviduct and uterus. Microscopically, the germigene is exactly similar to the testicle, and contains perfectly diaphanous cells with nuclei and nucleoles. These are the female germ-cells, which present no difference from those of the male. The nucleus of each of these cells divides into two, then into four, eight, &c., but there is no simultaneous division of the nucleole. At this point begins the differentiation of the male and female generative organs. At the bottom of the germigene the nuclei approach the wall of the cell containing them and push it before them, forming sacs into which the contents of the cell penetrate, and which by the gradual constriction of their base at last form secondary cells attached by a peduncle to the primary cell. These secondary cells are the future eggs, produced by a sort of exogenous generation of the female germ-cell. At this moment this bunch of cells passes into the vitellogene, the germ-cell or primary cell being in the centre, and the ova suspended like pears at its circumference by means of hollow peduncles. The vitellogene is perfectly passive, that is to say, it does not secrete the substance of the vitellus. This is produced in the germ-cell itself, and penetrates through the peduncles into the secondary cells, that is to say, into the ova. The membrane of the secondary cells thus becomes a vitelline membrane; and the nucleus becomes the germinal vesicle with its characteristic spot. The bunches of ova are placed one behind the other in the vitellogene in such a manner that the germ-cells always occupy the centre and the ova the periphery. The consequence of this arrangement is the formation of an apparent axis in the centre of the vitellogene, an appearance which is owing to the succession of the germ-cells; to this Meissner gives the name of *rachis* or *raphe*. At the moment of their entrance into the albuminogene the ova detach themselves from the germ-cell, and the dehiscence always takes place at the base of the peduncle, which remains attached to the ovum. The ova then become surrounded with albumen.

Meissner did not turn his attention particularly to the fecundation; but, nevertheless,—and this renders his observations of

more value,—he remarks, incidentally, that sometimes the peduncle remains widely open, and continues to project externally even after the ovum is surrounded with albumen, so that there remains a means of communication between the vitellus and the external world. We may, perhaps, observes Meissner, compare this structure of the ovum with the micropyle observed by Leuckart, J. Müller and Keber in the *Naiades* and *Holothuriæ*.

However, a few months afterwards, a new paper by Meissner* made its appearance, in which he not only confirms the discovery of a micropyle, but also that of the penetration of the spermatozoa into the ova of very different animals. The greater part of this work relates to the *Ascaris mystax* of the Cat, the same which had formed the subject of Nelson's observations; but he mentions several other species of *Ascarides*, a *Strongylus*, some *Lumbrici*, and the Rabbit. Meissner describes the formation of the spermatozoa and ova in the *Ascarides* as exactly the same as in *Mermis albicans*. The formation of the micropyle is due to the same circumstance. Nevertheless, he does not venture to regard this as a general type of development, for he has himself ascertained that it has exceptions. Thus, in *Strongylus armatus* the raphe, instead of being an apparent axis formed by the succession of germ-cells, is a *true raphe*. In this worm, the ova are a kind of diverticula of a pear-shape, suspended from a single vessel or vitelligenous tube, representing the germ-cells.

Nelson had seen the spermatozoa of *Ascaris mystax* penetrate into the ovum at all parts of its surface, and especially at one angle of this triangular ovum, to which he gives the name of the *broken edge*. Meissner shows, from the mode of formation of these ova, that they possess a vitelline membrane with a single aperture, through which he has himself repeatedly seen one or more spermatozoa penetrate. This opening, the micropyle, coincides exactly in position with the *broken edge* of Nelson. The cases in which the English anatomist thought he saw the penetration take place at other points, are probably to be attributed to errors. The spermatozoa observed by Meissner also coincide with the *spermatic cells* of Nelson, which Bischoff declared to be nothing but epithelial conules. Fecundation takes place at the moment when the ova arrive in the portion of the tube or sexual vessel which has already been denominated the albuminogene. The number of spermatozoa which penetrate by the micropyle is very variable, for Meissner has seen as many as ten in the interior of a single ovum. When fecundation is

* Beobachtungen über das Eindringen der Samenelemente in den Dotter. Zeitschr. für wiss. Zoologie, vi. Sept. 1854.

effected, the ovum completes its development in the manner described by Nelson.

In the *Lumbrici*, which were also studied by Meissner, things go on rather differently. In the ninth and tenth segments of their bodies, these animals possess four vesicles, which were formerly regarded as testicles, and the correct interpretation of which was first given by Von Siebold*, who states them to be seminal receptacles,—a function which also appears to be attributed to them by Van Beneden†.

These vesicles open externally by means of two small apertures, formerly mentioned by Leo‡. They have no communication of any kind with the ovaries, and it is nevertheless in their interior that the mature eggs are found. They probably arrive there from the exterior during copulation, so that in fact these organs should bear the name of common receptacles of the ova and semen, or of sacs of fecundation. The ovarian ova which possess a vitelline membrane and a germinal vesicle have lost these two elements when they arrive in the common receptacles, where they consequently swim completely naked. When there, they are assailed by the spermatozoa, which penetrate in crowds into the substance of the vitellus by a corkscrew-like movement. The united movements of the tails of all these spermatozoa at the surface of the ovum produce an appearance of waves. The segmentation of the ova commences in the receptacles, and they are afterwards extruded in a common capsule.

In this memoir Meissner confirms the discoveries of Barry, inasmuch as he also certainly saw spermatozoa in the interior of the ovum of the Rabbit, although he could not positively convince himself of the presence of the micropyle. This is a fact of great importance. We may always suppose that there is some error in speaking of the ova of *Anodontæ* and *Unios*; we may suppose that the spermatozoa which appear to be within them, may be in reality above or below them. But it is impossible to suppose that an object seen within the *zona pellucida* of the Rabbit may be situated above or below it. The object in question in fact is much too large, and it is impossible that the internal and external surfaces of the *zona pellucida* can be in focus at the same time. The same may be said, with still better reason, of the ova of the Frog, within which, as we have seen, Newport discovered spermatozoa.

* Lehrbuch der vergleichenden Anatomie.

† Report on a paper of Van Beneden's on the *Développement du Lombric terrestre*, in Bull. de l'Acad. Roy. de Belgique, xx.

‡ De Structura Lumbrici terrestris. Regiomonti, 1820.

Another memoir of Meissner's*, which followed immediately upon the former one, extended the results of his observations to two new classes of animals, namely the Insects and the Crustacea. The general result of the facts ascertained by him is, that the spermatozoa which are contained in the *receptaculum seminis* of the female (in Insects) after copulation, penetrate into the vitellus at the moment when the ova descend in the vagina. For this purpose, these spermatozoa are obliged to traverse an opening or micropyle, which exists both in the chorion and the vitelline membrane. He enumerates a long series of insects in which he observed the micropyle, and sometimes also the presence of spermatozoa in the interior of the membranes. The chorion of the eggs of Insects, and particularly of the Diptera, is often adorned with very regular geometrical designs, and the micropyle is very easily found, as it generally occupies the centre of an elegant rosette situated at one of the extremities of the egg. It is a curious circumstance, that this micropyle of the eggs of Insects is so easily seen, that it has been described and figured in a great many instances, although its function was never suspected. It was regarded only as an ornament, but not as an opening. Swammerdamm, Rösel, De Geer, Réaumur, Kirby and Spence, Ratzeburg, Sepp, Léon Dufour, Herold, Hartig and others have described and figured the peculiarities of the surface of the eggs of a great many insects, —peculiarities which all appear to be referable to the existence of the micropyle. Moreover the observations of Meissner alone would be sufficient to lead us to suppose the general diffusion of this structure of the egg in the whole class of Insects, since he has ascertained the existence of the micropyle in Diptera (*Musca, Tipula, Culex*), Coleoptera (*Lampyris, Elater, Telephorus*), Lepidoptera (*Adela, Pyralis, Tortrix, Euprepia, Liparis, Pieris*), Hymenoptera (*Tenthredo, Polistes, Spathius*), and Neuroptera (*Agrion, Panorpa*). Subsequently Leuckart has published a very remarkable work† on the micropyle of Insects, of which, unfortunately, only the first hundred pages have as yet (June 1855) appeared. In this he describes the micropyle in the eggs of at least 200 species, which scarcely leaves room to doubt of the universality of this arrangement in Insects. In a great number of these species he has even directly observed the entrance of the spermatozoa by the micropyle, or at least has found them in

* Beobachtungen, &c. No. ii. Zeitschr. für wiss. Zool., Sept. 1854.

† Ueber die Micropyle und den feinen Bau der Schalenhaut bei den Insecteneiern. Müller's Archiv, 1855. In the 'Handwörterbuch der Physiologie,' article *Zeugung*, Leuckart had already mentioned the micropyle as an attenuated part of the chorion, *which might probably play some part in fecundation*.

the interior of the egg. Leuckart has even arrived at general laws with regard to the structure of the micropyle in the different orders. In the portion of this memoir which has now appeared, only the Diptera, the Hemiptera and the Lepidoptera are referred to. The following is a summary of these laws:—1. In all the *true* Diptera (not including the Rhipiptera) the micropylian apparatus consists of a simple opening, situated at the anterior pole of the egg, or at least in the neighbourhood of this pole. 2. In the Hemiptera the micropyles are almost always more numerous, and not far from the anterior pole. 3. In the Lepidoptera the micropyles are always multiple, forming a variable number (usually four or six) of canals, which rise from a common central fossa situated at the anterior pole, and pierce through the envelopes of the egg in a radiating direction. As regards the Crustacea, Meissner has ascertained the existence of the micropyle in the *Gammarus pulex* of our brooks.

It is curious that Bischoff, after placing himself in the ranks of the defenders of the penetration of the spermatozoa into the ovum, should have again taken up the pen* with a certain degree of asperity to confute the discoveries of Meissner, which appear to form the most brilliant point, and in a manner the crown of their productions. Nevertheless, this does not in any way invalidate the theory of the penetration of the spermatozoa into the ovum, which is now permanently received into the science. Bischoff in fact only questions the description given by Meissner of the formation of the ova, and more especially of the spermatozoa in *Ascaris mystax*. Meissner had regarded as spermatozoa the same corpuscles which Nelson had previously admitted as such, whilst Bischoff persists in regarding them only as epithelial conules. On the other hand, Meissner, in describing the formation of the ova by means of diverticula of a germ-cell, had differed from Nelson, who had seen the young ova totally destitute of vitelline membrane. Bischoff adopts the opinion of Nelson, and positively denies the existence of the germ-cells and their diverticula, *at all events in the Ascaris* of the Cat. But he is greatly embarrassed by his epithelial conules when it becomes necessary to find the true spermatozoa, which, he says, must nevertheless penetrate into the egg. Notwithstanding all this, Meissner, in a subsequent work†, remains faithful to his theory. The future will decide this question, which is only accessory here, seeing the abundance of other materials.

* Ueber Ei- und Samenbildung und Befruchtung bei *Ascaris mystax*. Zeitschr. für wiss. Zool., Feb. 1855.

† Beiträge zur Anatomie und Physiologie der Gordiaceen. Zeitschr. für wiss. Zoologie, May 1855.

The numerous facts to which we have drawn attention prove more than sufficiently that fecundation is effected by an actual penetration of the spermatozoa into the interior of the ova, and that very often, if not always, this penetration takes place through a micropyle. It remains to be seen in what envelope of the ovum this exists, and if it is always possible to explain its formation in the manner of Lovén* and Leuckart, or in that of Meissner. Johannes Müller has, not long since†, indicated a peculiar structure in the external membrane of the ova of certain fishes, especially our river fish,—a structure which has also been investigated by Lereboullet‡. This membrane is pierced by a multitude of little canals, passing from one surface to the other, and dilating into a funnel-like form at each surface, so that the membrane presents a facetted appearance. This structure is particularly remarkable in the Perch (*Perca fluviatilis*), the egg of which has a very thick external membrane; but it is equally striking from its elegant appearance in the Ruffe (*Acerina cernua*) and the Sticklebacks (*Gasterosteus trachurus, lagurus, pungitius*, &c.). This structure appears to have been previously seen by Vogt§, who describes a shagreened appearance of the cortical membrane in the *Coregonus palea*; but he seems not to have remarked that this appearance was due to the presence of a multitude of little canals, of which the number, according to J. Müller, amounts to more than 1,1000 in the egg of the Perch. It is in this membrane that the micropyle is situated‖. It is remarkable that this membrane presents a great analogy in structure with that in which the micropyle is placed in the *Holothuriæ*. This latter is characterized by a sort of striation,—an appearance which is due, according to the opinion of J. Müller, to a multitude of little prisms placed perpendicularly upon the membrane. It is the membrane that Müller regards as the cortical membrane (*Schalenhaut*)¶, and Leuckart as the vitelline membrane**.

* Bidrag till kännedomen om utvecklingen af Mollusca acephala. Stockholm, 1848.

† Ueber zahlreiche Porenkanäle in der Eikapsel der Fische. Monatsber. der Berl. Akad., March 1854.

‡ Ann. des Sci. Nat. 1854.

§ Embryologie des Salmones, in Agassiz, Hist. nat. des Poissons d'eau douce de l'Europe centrale. 1842.

‖ This micropyle, or at least the funnel at the bottom of which it opens, is sometimes so large, that Bruch has found it with the naked eye in the egg of the Trout (*Fario lacustris*) and the Salmon (*Salmo salar*). Zeitschr. für wiss. Zoologie, May 1855. The funnel itself was already known to Von Baer in *Cyprinus blicca*,—Entwickelungsgeschichte der Fische. Leipzig, 1835.

¶ Ueber die Larven und die Metamorphose der Holothurien und Asterien. 1850.

** Zusatz zu Bischoff's Widerlegung, &c.

It must not be supposed that the shagreened envelope of the Fishes' egg is the analogue of the chorion of the Mammalia, or of the shell, or the shell-membrane of Birds. In fact, the chorion and the membrane of the shell are not formed until after fecundation, so that it would be useless to seek in them for a micropyle; the former does not exist in the Graafian vesicles of the Mammalia, nor the latter in the ovisacs of Birds. The shagreened membrane of Fishes, or capsular envelope, exists in the ovarian follicles, and consequently before fecundation, so that the spermatozoa must traverse it to effect that operation. It is therefore furnished with a micropyle, and must be compared with the *zona pellucida* of the Mammalia and the vitelline membrane of Birds. The *zona pellucida* of the mammalian ovum, the vitelline membrane of Birds' eggs, the shagreened membrane of those of Fishes, the envelope with a crystalline structure of the ova of the *Holothuriæ*, the cortical membrane of those of the *Naiades*, the vitelline membrane of those of *Mermis* and *Ascaris*, and the external envelope of the eggs of Insects and of *Gammarus pulex*, are therefore one and the same thing, and may be designated the *membrane of the micropyle**. It is true that the ova of *Gasterosteus* and those of other fishes have an apparently homogeneous membrane beneath the membrane of the micropyle, and, to establish a complete analogy in the ova of other animals, it would be necessary to ascertain the existence of this second membrane in them. Barry† has already asserted, that he observed a membrane between the *zona pellucida* and the vitellus in the Mammalia. The Insects possess a second membrane, furnished like the first with a micropyle. Müller‡ speaks of a membrane which immediately envelopes the vitellus in the *Holothuriæ*, of which, however, Leuckart§ denies the existence. Keber‖ asserted that in the *Naiades*, besides the cortical membrane, he recognized a vitelline membrane, and even a membrane

* It is true that we do not yet positively know whether the *zona pellucida* possesses a micropyle, although Barry should have seen it, and Meissner once ascertained the presence in it of an opening which did not appear to be torn. There remain the Reptiles, of which the vitelline membrane, to judge from Newport's observations on the ova of the Frog, must be permeated in all parts by the spermatozoa. But this does not appear to be a general rule amongst the Reptiles, nor even amongst the Batrachia, for, according to an unpublished discovery of Meissner's, the ova of the common Tree Frog (*Hyla arborea*) appear to possess a micropyle.

† Researches in Embryology, Third Series. Phil. Trans. 1840. It is his "proper membrane of the substance by which the germinal vesicle is surrounded."

‡ Echinodermen, 4te Abhandlung, 1850.

§ Zusatz, &c.

‖ Ueber den Eintritt der Samenzellen in das Ei. 1853.

of the albumen. This however appears to be of but little importance, as it is very possible that this membrane may sometimes be present and sometimes absent. It is only necessary to suppose, that where it occurs it is pierced by a second micropyle, or that the spermatozoa can pass through its tissue. A more important point, in our opinion, is the complicated structure presented by the membrane of the micropyle in the Fishes, the *Holothuriæ*, the Insects*, and probably other animals; for there are many ova in which the micropyle has not yet been discovered, but in which the external membrane presents a shagreened structure, resembling that of the membrane of the micropyle in Fishes. This is the case, for example, in the ova of the *Echinorhynchi*, &c. But this complicated structure is an obstacle to the theory of Meissner upon the formation of the ova, of much greater force than all the objections which Bischoff was able to bring against it. Is it possible to regard a whole so complex as this membrane as a simple cell? There can be no doubt that we must reply in the negative. We must therefore either reject the observations of Meissner upon the formation of the ova of *Mermis*, or, as they have such an impress of truth that it is difficult not to yield to them, admit that the ovum is formed in very different modes in the series of created beings. The latter opinion has nothing improbable about it†.

The penetration of the spermatozoa into the ovum is a fact now acquired to science; but this penetration may take place in very different manners, and we can already distinguish three principal types:—

1. Penetration through a micropyle; a mode of fecundation which appears to be very widely spread, as its existence has already been ascertained in Echinodermata, Worms, Insects, Crustacea and Fishes, and perhaps also in Reptiles (*Hyla*) and Mammalia (the Rabbit).

2. Penetration by all points of the surface of the ovum; observed by Newport in the true Frogs. It is true that we may in this case suspect an error, and that it is possible that a micropyle may some day be discovered in the Frogs; but is it not surprising that such careful researches as those which have been

* It is probable, however, that it is not in the external membrane of the eggs of Insects that we find the analogue of the membrane of the micropyle in other animals. It is probably rather the inner membrane, which is also traversed by the micropyle. Leuckart however believes he has seen instances in which the chorion (or outer membrane) *alone* was traversed by the micropyle.

† More especially as Lovén and Leuckart have shown that the ova are formed in a very different manner in *Modiolaria*, *Cardium*, and the *Naiades*. The multiple micropyle of the eggs of the Hemiptera and Lepidoptera also indicates a very different mode of formation.

made upon the ova of the Batrachia by many authors * have not led to the discovery of the micropyle in them?

3. Penetration directly into the naked vitellus. It is certain, in fact, that the mode of origin of the ova described by Meissner in *Mermis albicans*, *M. nigrescens*, and several *Ascarides*, is not general even amongst the Nematoid worms. A great many ova only obtain an envelope at a very late period, and are probably fecundated before they possess one, so that they do not require the presence of a micropyle. Meissner himself has seen the spermatozoa penetrate directly, and in crowds, into the ova of the Earthworm, at a period when they are completely destitute of an envelope. As regards these, Meissner supposes that they originally possess a membrane which disappears before fecundation. This is very possible, as we know that a similar disappearance takes place, although at a later period, with the vitelline membrane of the ova of Gasteropoda and Insects (Rathke, Kölliker, Zaddach, Leuckart †).

[To be continued.]

XXV.—*On some species of* Epilobium.

By Charles C. Babington, M.A., F.R.S. &c.

[Concluded from p. 247.]

We will now turn our attention to the species allied to *E. alpinum*, which present some difficulty, from there being probably two plants which pass by that name. Of this Dr. Godron was well aware when preparing the account of this genus for the

* Swammerdamm, Biblia Naturæ. Leeuwenhoeck, Arcana Naturæ. Rœsel, Hist. Nat. Ranarum nostratium; Nürnberg, 1758. Spallanzani, Diss. relatives à l'Hist. Nat. des Animaux et des Végétaux, 1789. Prevost and Dumas, Ann. des Sci. Nat. tome ii. Rusconi, Développement de la Grenouille commune; Milan, 1828; and Amours des Salamandres, 1821. Baer, Lettre sur la Formation de l'Œuf, 1829; Repertorium; Müller's Archiv, 1834. Reichert, Entwickelungsleben im Wirbelthierreich; Berlin, 1840. Vogt, Untersuchungen über die Entwickelungsgeschichte von der Geburtshelferkröte; Solothurn, 1842. Bell, British Reptiles. Newport on the Impregnation of the Ovum in the Amphibia, Phil. Trans. 1851 and 1853.

† We might add to these a fourth mode of fecundation, if we admitted, with Remak (Müller's Archiv, 1854), that the spermatozoa are only destined to transport a substance serving to effect fecundation (*die Träger einer samenähnlichen Substanz*). This substance being capable of passing through the little canals of the external membrane of the ova of Fishes, it would not be necessary that the spermatozoid itself should penetrate into the ovum in these animals. But we are already acquainted with the micropyle in many fishes, and it will probably be discovered in the others, which renders this theory very useless.